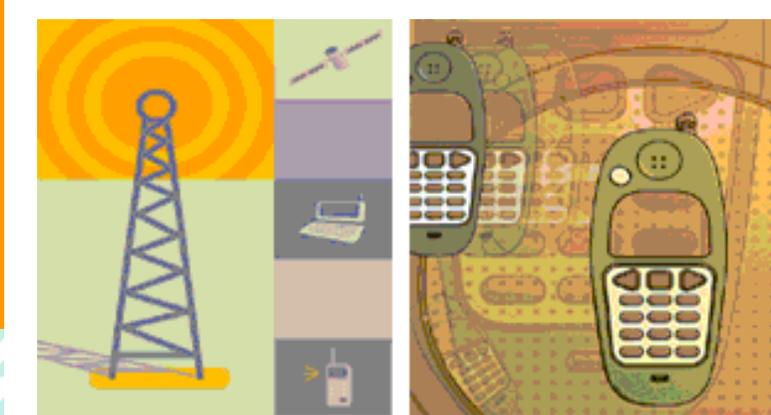Preliminary version
For final workshop version, directly contact the author

Digital IF Revised Submission
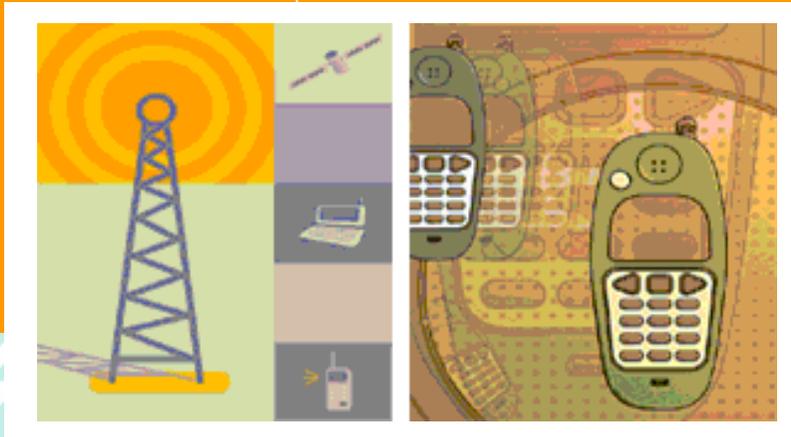
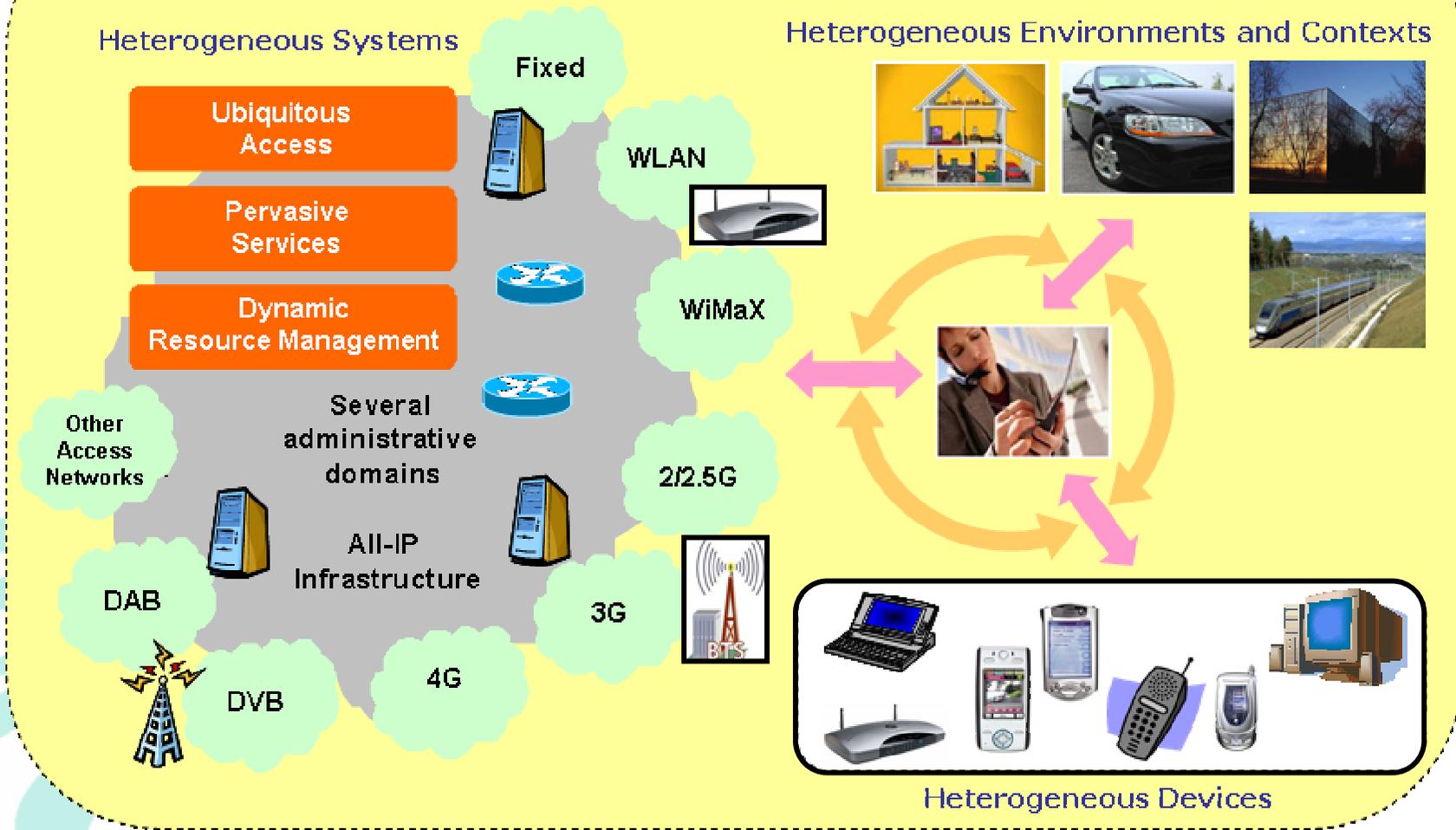*A concrete example of collaboration between an industrial forum and a standardization body*

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THALES

Introduction

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THALES 2

wireless world initiative

End-to-End Reconfigurability: Enabler of the Seamless Experience

Heterogeneous Systems

- Ubiquitous Access
- Pervasive Services
- Dynamic Resource Management

Fixed

WLAN

WiMaX

Several administrative domains

All-IP Infrastructure

Other Access Networks

DAB

DVB

2/2.5G

3G

4G

BTS

Heterogeneous Environments and Contexts

Heterogeneous Devices

THALES

Reconfigurable Radio Equipment

To be completed

Any Radio application is needing a Transceiver Sub-system

- ✓ Whatever the domain

- ✓ Whatever the neighboring sub-systems in the equipment

- ✓ Whatever the waveform / RAT
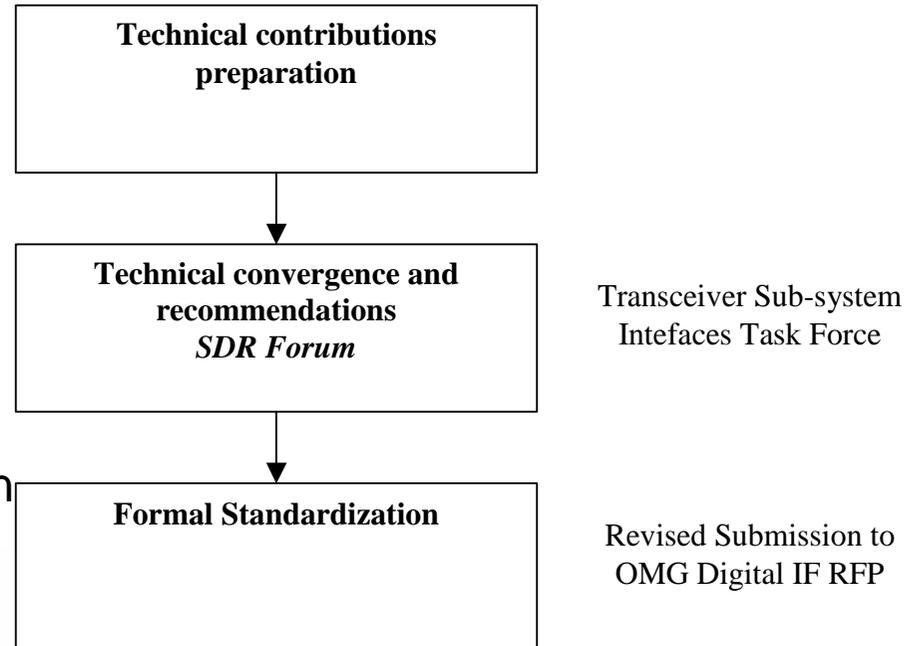
Transceiver Reconfigurability

- ✓ A flexible Transceiver is to be realized

- ✓ The exhaustive sets of dependencies to and from the hosted Waveform software is needed

- ➔ A unified way to characterize Transceiver configuration states is needed

As of today…

- ✓ Several hardware-level standardization
  - ✓ OBSAI, CPRI, VITA 49
  - ✓ ➔ implementation enablers

- ✓ No known structured API effort on this matter
  - ✓ OMG Digital IF is the right repository for this effort

Context information

- ✓ OMG
  - ✓ Digital IF RFP released by SBC beg 05
  - ✓ Initial submission in May 05
  - ✓ June 06 Technical Meeting, Boston
    - ✓ Presentation of status on THALES works for Revised submission
    - ✓ SDR Forum added to the voting list

- ✓ SDR Forum
  - ✓ June 06 – General Meeting, Vancouver
    - ✓ Review of OMG slides
    - ✓ Interest raised in the System Interfaces WG & SCA API WG
  - ✓ Sept 06 – General Meeting, Munich
    - ✓ Presentation in SCA API WG
  - ✓ Nov 06 – Technical Conference
    - ✓ Presentation of formal article
    - ✓ Creation of Transceiver Sub-systems Interfaces Task Force (TSI TF)

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THALES   6

✓ **Transceiver Sub-system Interfaces are a subject to progress on**

✓ **Context**

  ✓ Technical contribution from various horizons

  ✓ Technical discussions to converge and issue recommendations for standard achievements

  ✓ Various possible standardization bodies

Technical contributions preparation

↓

Technical convergence and recommendations *SDR Forum*

Transceiver Sub-system Intefaces Task Force

↓

Formal Standardization

Revised Submission to OMG Digital IF RFP

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THALES 7

SDR Forum – TSI Task Force

OMG – SBC

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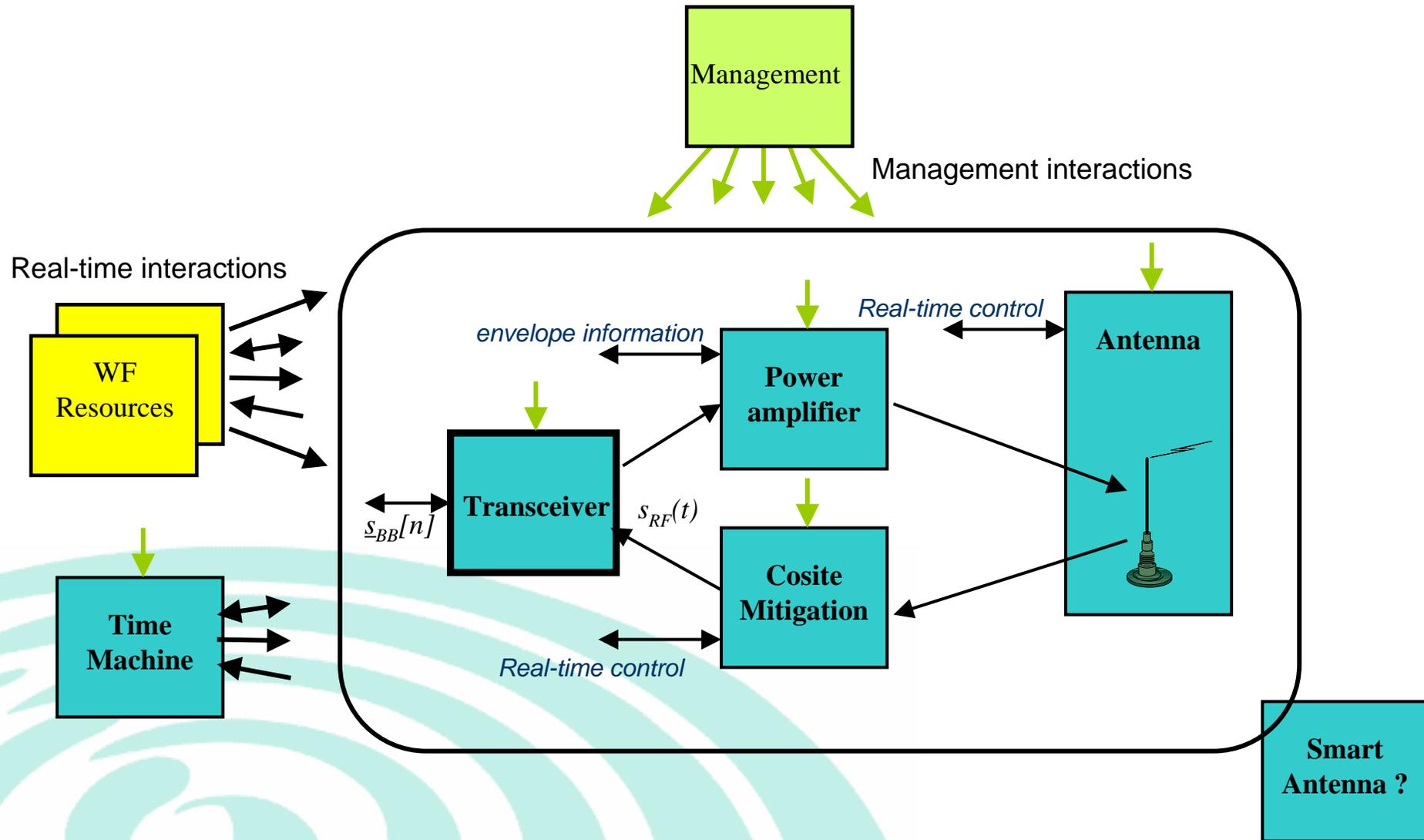# Some more details about Transceiver

Transceiver is defined as the complete set of treatments bringing, on the transmit data path, the complex base-band samples up to the low power RF analogue signal, and reciprocally on the receive data path. Any management and control features necessary for Transceiver usage are part of the Transceiver sub-system.

"Transceiver Sub-system" terminology insists on the fact Transceiver is one of the prime sub-systems intrinsically constitutive of any radio equipment (such as Power Amplifier, Cosite Mitigation, Antenna, …)

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Management

Management interactions

Real-time interactions

WF Resources

Time Machine

envelope information

Real-time control

Antenna

Power amplifier

$\underline{s}_{BB}[n]$

Transceiver

$s_{RF}(t)$

Real-time control

Cosite Mitigation

Real-time control

Smart Antenna ?

THALES
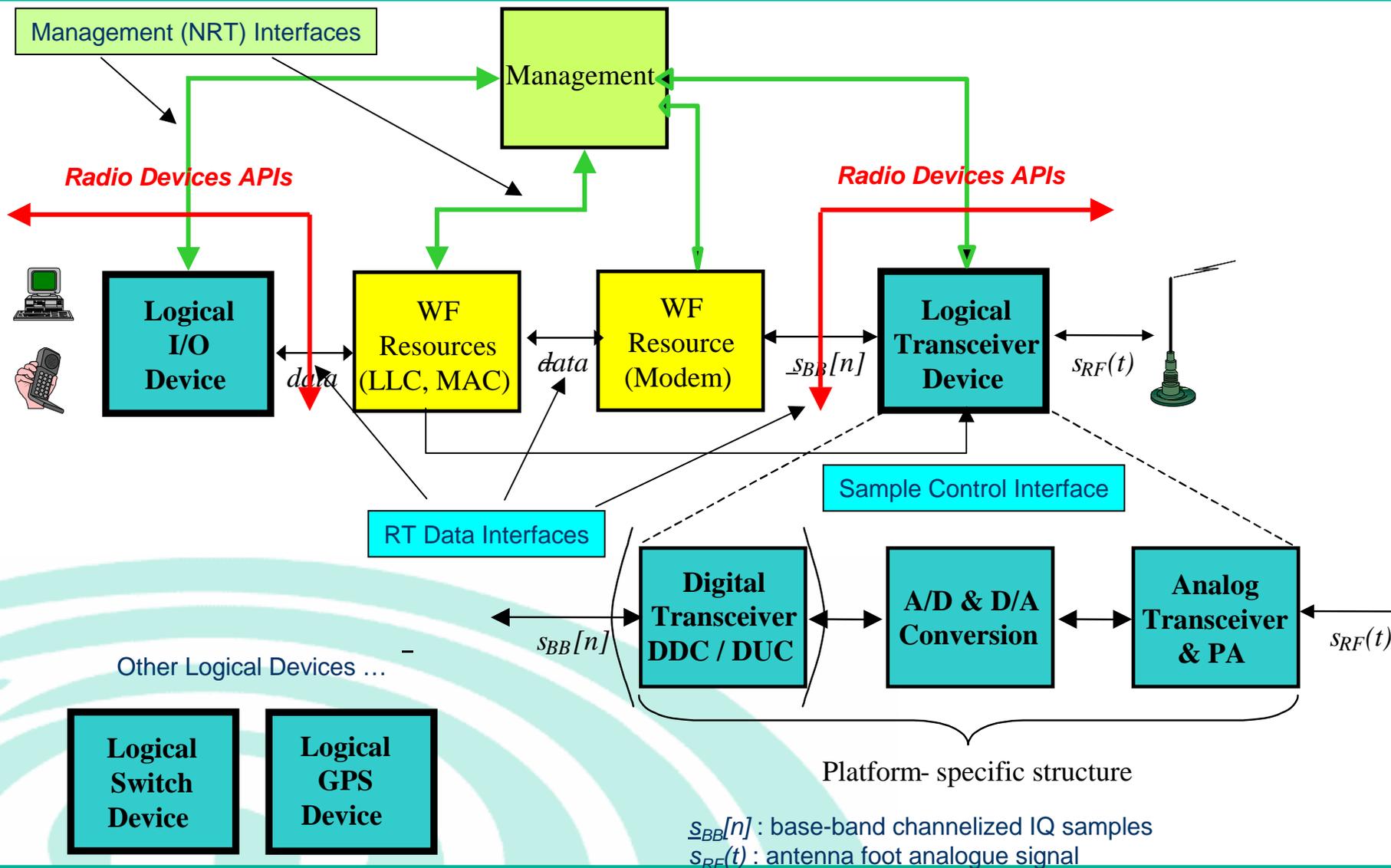
Transceiver inside Reconfigurable Radio Equipments

- ✓ A flexible Transceiver is part of the equipment

- ✓ The exhaustive sets of dependencies to and from the hosted Waveform software is needed

➔ A unified way to harness Transceiver reconfiguration is needed

Transceiver to support Waveform Resources portability

- ✓ The Transceiver has very specific implementation choices

- ✓ The Waveform software needs to make abstraction of such choices

➔ An abstraction of the Transceiver implementation is needed

As of today…
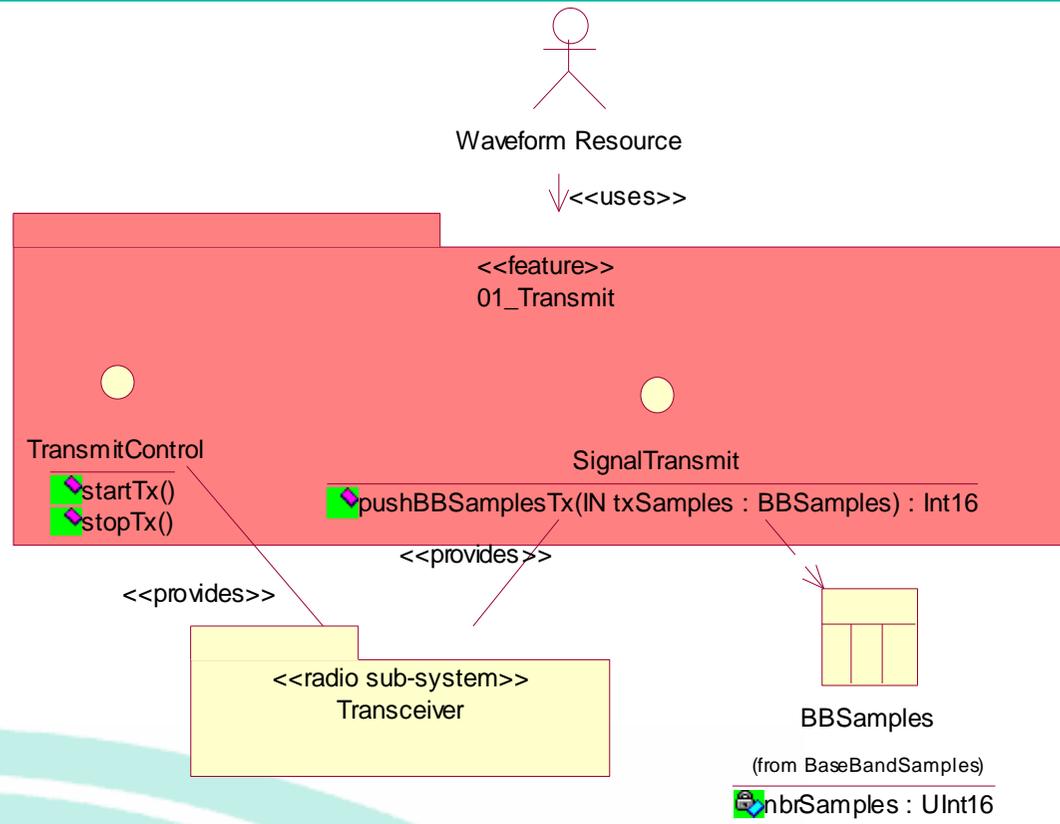
- ✓ Several standardizations of implementation enablers (VITA, OBSAI, CPRI…)

- ✓ No known structured API effort

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THALES   12

Logical Tranceiver Device position

Management (NRT) Interfaces

Management

Radio Devices APIs

Radio Devices APIs

Logical I/O Device

WF Resources (LLC, MAC)

$data$

WF Resource (Modem)

$data$

$s_{BB}[n]$

Logical Transceiver Device

$s_{RF}(t)$

RT Data Interfaces

Sample Control Interface

Other Logical Devices …

Logical Switch Device

Logical GPS Device

Digital Transceiver DDC / DUC

$s_{BB}[n]$

A/D & D/A Conversion

Analog Transceiver & PA

$s_{RF}(t)$

Platform- specific structure

$s_{BB}[n]$: base-band channelized IQ samples
$s_{RF}(t)$: antenna foot analogue signal

THALES 13

Waveform Resource

<<uses>>

<<feature>>
01_Transmit

TransmitControl
- startTx()
- stopTx()

SignalTransmit
- pushBBSamplesTx(IN txSamples : BBSamples) : Int16

<<provides>>

<<provides>>

<<radio sub-system>>
Transceiver

BBSamples

(from BaseBandSamples)

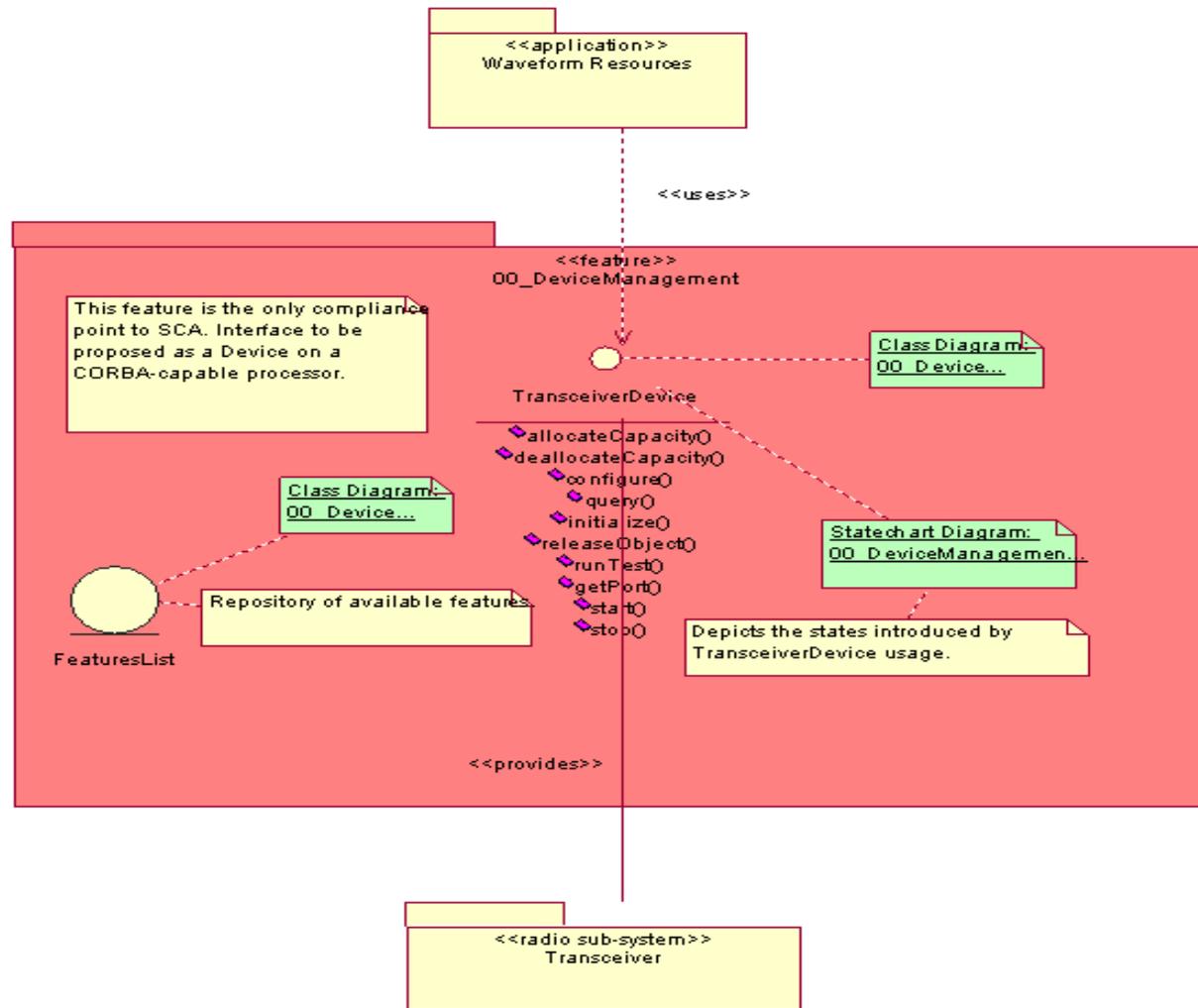nbrSamples : UInt16

SignalTransmit

Enable the subscriber to transfer base-band samples to the Transceiver for transmission.

TransmitControl (drafted)

This interface enables Waveform Ressource to have a real-time command on the beggining of transmission. The beginning could be linked with the Hopping Mode Control (through a Dwell Number) or a Time Mangement subsystem.

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THALES

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Waveform Resource

<<uses>>

<<feature>>
04_FrequencyHoppingControl

| Class Diagr... | Class Diagr... | Class Diagr... |

DwellSetting

◇setDwellProfile()

FrequencyFeeding

◇pushFrequency ()
◇flushFrequencies (provision)()

DwellTuning

◇shiftDwellProfile()
◇expandDwellProfile()

<<radio sub-system>>
Transceiver
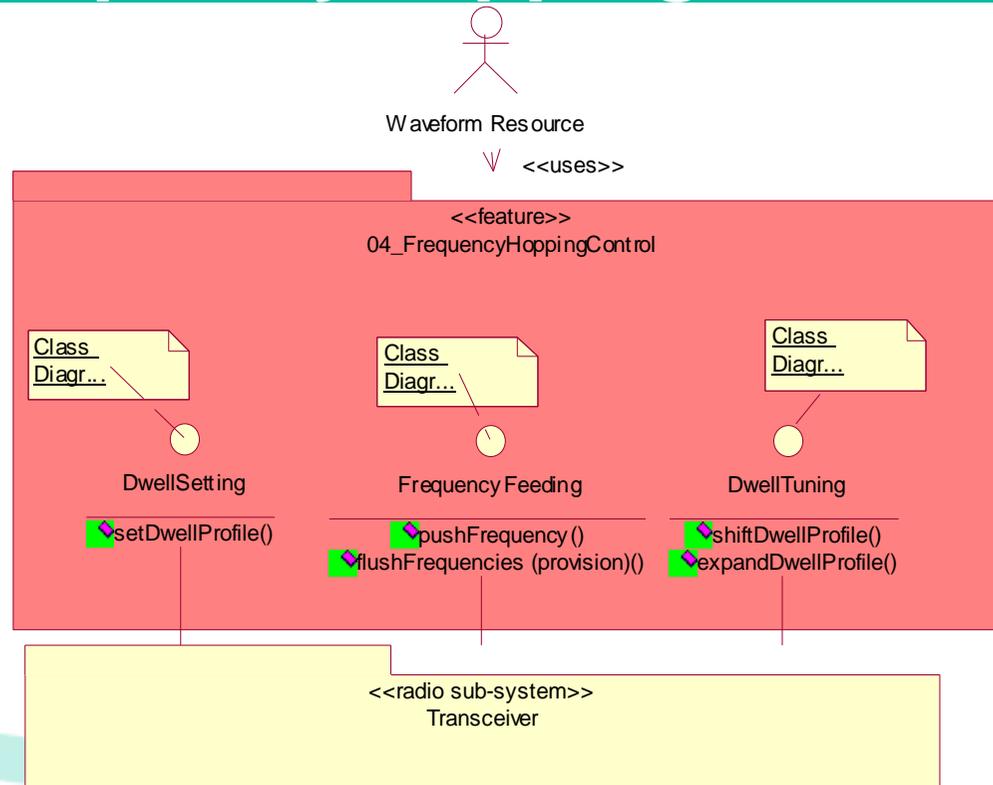
DwellSetting

Enable the subscriber to define a new Transceiver dwell profile and specifies when it should be applied.
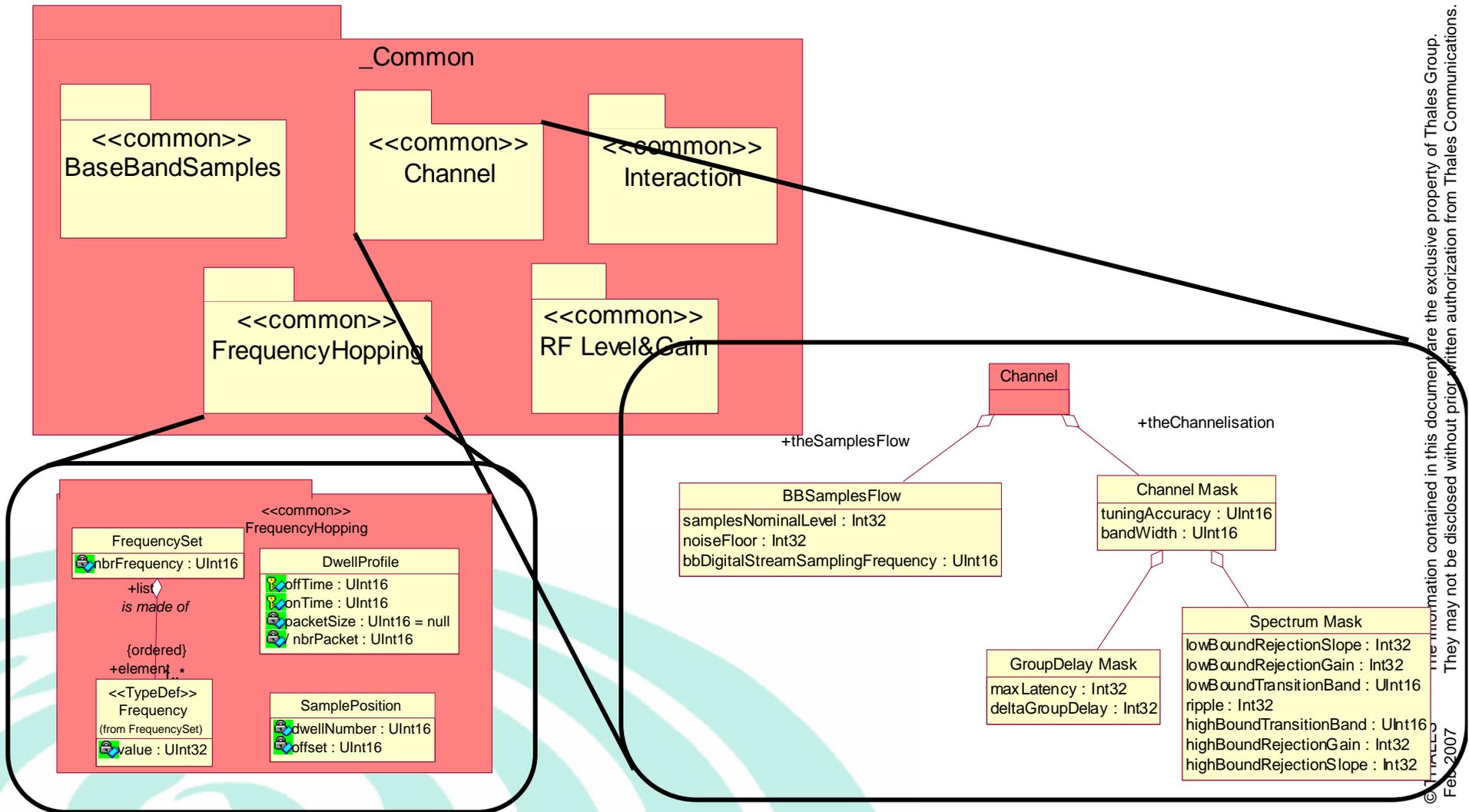
DwellTuning

Enables subscriber to correct dwell profile temporal positioning without redefining dwellProfile.
Namely used by an equipment in reception to mitigate clock drifts with the transmitting equipments it receives.
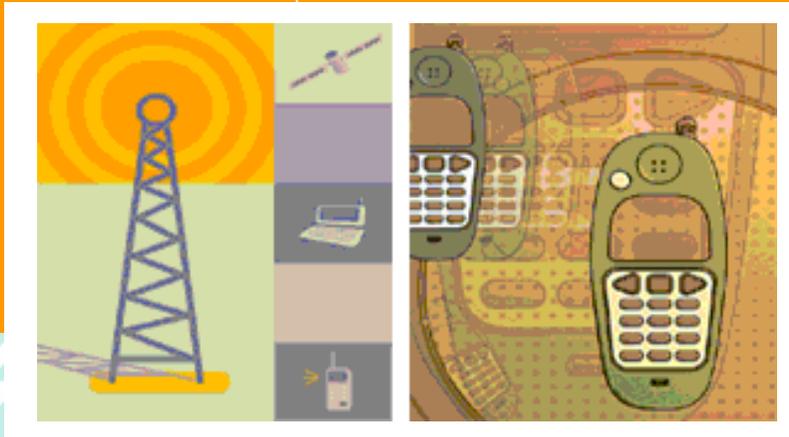
FrequencyFeeding

Enables subscriber to change the RF frequency

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wireless world initiative

_Common

<<common>>
BaseBandSamples

<<common>>
Channel

<<common>>
Interaction

<<common>>
FrequencyHopping

<<common>>
RF Level&Gain

Channel

+theSamplesFlow

+theChannelisation

BBSamplesFlow
samplesNominalLevel : Int32
noiseFloor : Int32
bbDigitalStreamSamplingFrequency : UInt16

Channel Mask
tuningAccuracy : UInt16
bandWidth : UInt16

<<common>>
FrequencyHopping

FrequencySet
nbrFrequency : UInt16

+list
is made of

{ordered}
+element   *

DwellProfile
offTime : UInt16
onTime : UInt16
packetSize : UInt16 = null
nbrPacket : UInt16

<<TypeDef>> Frequency (from FrequencySet)
value : UInt32

SamplePosition
dwellNumber : UInt16
offset : UInt16

GroupDelay Mask
maxLatency : Int32
deltaGroupDelay : Int32

Spectrum Mask
lowBoundRejectionSlope : Int32
lowBoundRejectionGain : Int32
lowBoundTransitionBand : UInt16
ripple : Int32
highBoundTransitionBand : UInt16
highBoundRejectionGain : Int32
highBoundRejectionSlope : Int32

Defining the Transceiver Facility PIM

THALES

18

Technical approach

- ✓ OMG Model Driven Architecture is governing the efforts

- ✓ Platform Independent characterization
  - ✓ Guidelines for Facility definition
  - ✓ The Transceiver Facility itself
  - ✓ Waveform-specific bindings
  - ✓ Platform-specific bindings
  - ✓ Support by formal UML PIM (Platform Independent Model)

- ✓ Platform Specific characterizations
  - ✓ For waveforms, platforms and integrated equipments implementations
  - ✓ Taking into account implementation choices: design principles, HW/SW breakdown, processing environments…
  - ✓ Support by formal UML PSM (Platform Specific Model)

- ✓ Close relationship to existing standards Management approach
  - ✓ Usage of Device interface
  - ✓ Valid for SCA and OMG SWRadio Spec

Transceiver Facility

✓ A set of concepts that support requirement specifications towards Transceiver sub-systems

✓ To become a normative part of the OMG Digital IF Revised Submission

✓ Organized as a set of <u>Features</u> supported by a set of <u>Common concepts</u>

Common concepts

✓ Concepts shared across different Features

✓ Captured separately

✓ The fundamental concepts enabling the Transceiver abstraction

- ✓ Definition of Features
  - ✓ Correspond to unitary capabilities composing a Transceiver
  - ✓ Are the normative compliance points to the Facility
  - ✓ The Facility is made of a list of Features
  - ✓ Are describing the transceiver with rigorous implementation abstraction

- ✓ Binding from Features to specifications
  - ✓ Enables to specialize according to the usage context
  - ✓ Enables to benefit from a consistent set of modelling artifacts

- ✓ Content of Features – Any combination of
  - ✓ Interfaces, operations, arguments
  - ✓ Attributes, types
  - ✓ State machines
  - ✓ Non functional requirements (esp. Real-time)
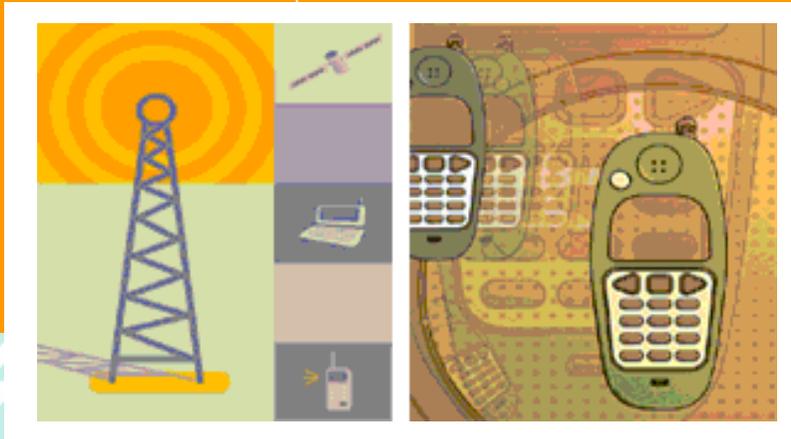 - ✓ Applicable sequence diagrams

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- ✓ Nature of the Facility PIM
  - ✓ A formal UML 1.x model
  - ✓ Explanatory figures and technical notes

- ✓ Root logical package: « Transceiver Facility »
  - ✓ Sub-package « Features »
  - ✓ Sub-package « Common concepts »

- ✓ Inside « Features »
  - ✓ As many sub-packages as features
  - ✓ Each stereotyped <<feature>>
  - ✓ Interfaces grouped into a sub-package stereotyped <<API>>

- ✓ Inside « Common concepts »
  - ✓ As many sub-packages as common concepts
  - ✓ Each stereotyped <<concept>>
  - ✓ Any appropriate modelling artifacts

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Using Transceiver Facility PIM…

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THALES

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The considered cases

1) **<u>Waveform function design</u>**

   - With illustration

2) **<u>Flexible Transceiver functional specification</u>**
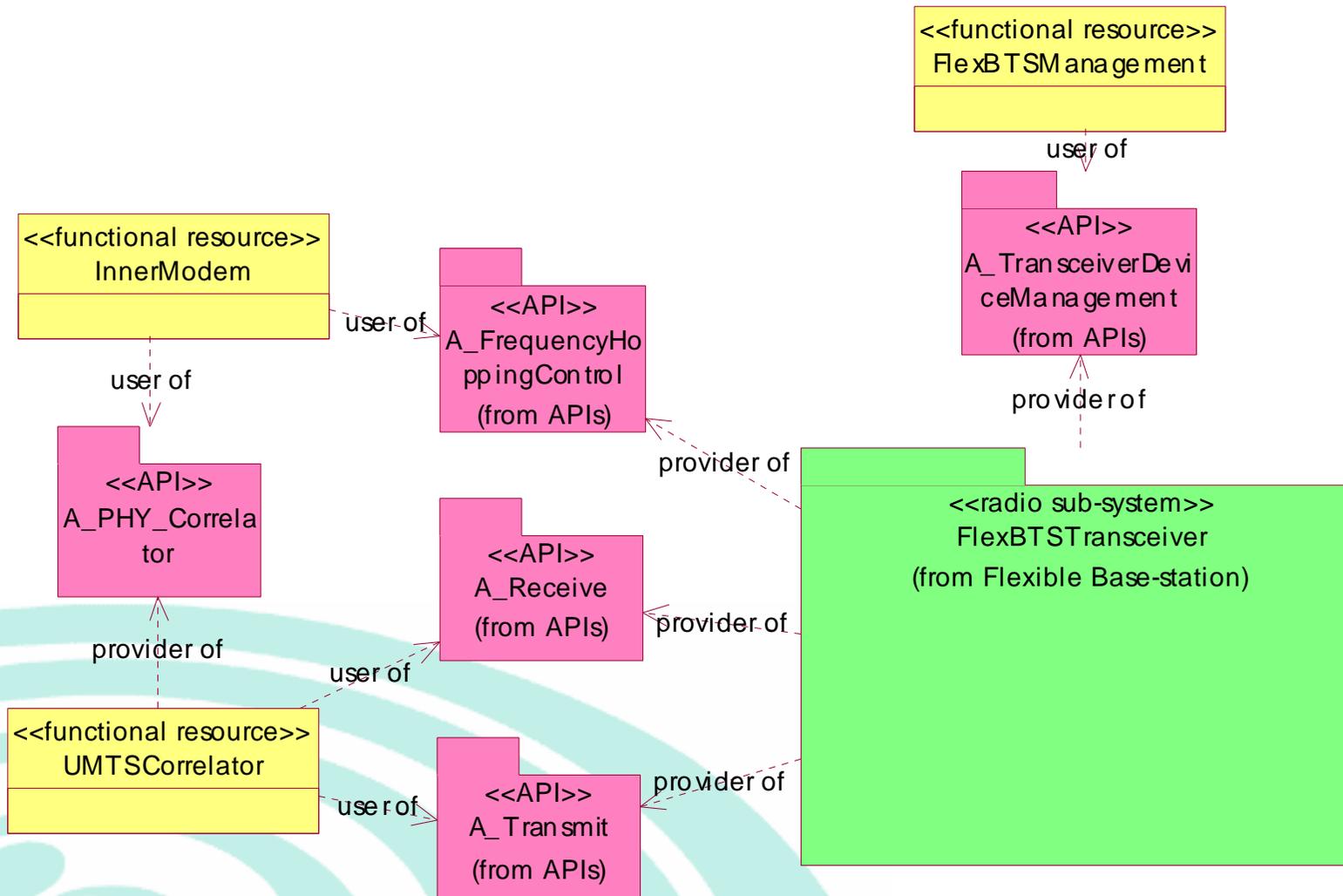
3) **<u>Flexible Transceiver design & implementation</u>**

4) **<u>Waveform design & implementation</u>**

   - With illustration

- ✓ Objective
  - ✓ Defining the waveform decomposition into functionalities
    - ✓ Some will become SCA/OMG resources
    - ✓ Some will become radio-domain sub-system of the platform
  - ✓ A formal description is realized, with modelling tool support
  - ✓ This formal description can be executable, with simulation tool support
- ✓ Transceiver is one module of the waveform functional design
  - ✓ Any radio application needs one
  - ✓ Specification is kept abstracted from the implementation
  - ✓ Dependendencies with resources are striclty defined
- ✓ A « waveform binding » is thus realized from the Facility
  - ✓ Selection of the sub-set of requested features
  - ✓ Values of dimensioning parameters
  - ✓ Which port connections between Resources and Transceiver
  - ✓ Interaction types and expression of timing requirements

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THALES   26

- ✓ Objective
    - ✓ Specifying the flexible Transceiver part of a Reconfigurable Radio Equipment
    - ✓ Formalizing requirements allocation in equipment development flow
    - ✓ Define or evaluate compliance with waveform requirements
- ✓ A « Platform binding » is realized from the Facility
    - ✓ Specification of the supported features
    - ✓ Definition of the supported functional configurations
        - ✓ Explicitly referencing waveform-bindings
        - ✓ Expressing accessible ranges of values for some performance attributes
    - ✓ Definition of real-time constraints performance
- ✓ Example: the Digital IF initial submission has the information content of a platform binding from the Facility tailored for the PEA AL waveforms

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THALES 27

- ✓ Objective
  - ✓ Designing Transceiver in compliance with functional requirements
  - ✓ Introducing platform-specific assumptions

- ✓ Key happenings
  - ✓ Architecture of the Flexible Transceiver is defined. E.g.
    - ✓ Analogue transposition technology
    - ✓ A/D & D/A conversion
    - ✓ Digital up and down conversion
  - ✓ Computational resources are defined
    - ✓ Those implementing Transceiver treatments
    - ✓ Those from which the Transceiver will be accessed
  - ✓ Logical APIs from previous step are mapped into the processors

- ✓ Usage of implementation standards is possible at that stage (e.g. VITA 49, OBSAI, CPRI, …)

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- ✓ Objective
  - ✓ Defining assumptions relative to waveform resources and transceiver
  - ✓ Taking into account platform-specific assumptions
    - ✓ Processing units operating environment choices
    - ✓ Mapping of Transceiver APIs into processors
  - ✓ Mastering the relation with Transceiver for those connected to it
- ✓ Key happenings
  - ✓ The mapping of the waveform resources to processing units is realized
  - ✓ Ports connections are realized
    - ✓ Local or remote
    - ✓ Automated (CORBA) or manual process
  - ✓ The resources sharing issues are resolved
    - ✓ Scheduling: tass, priorities, stacks dimensioning
    - ✓ Memory usage
    - ✓ Connectivity access arbitration

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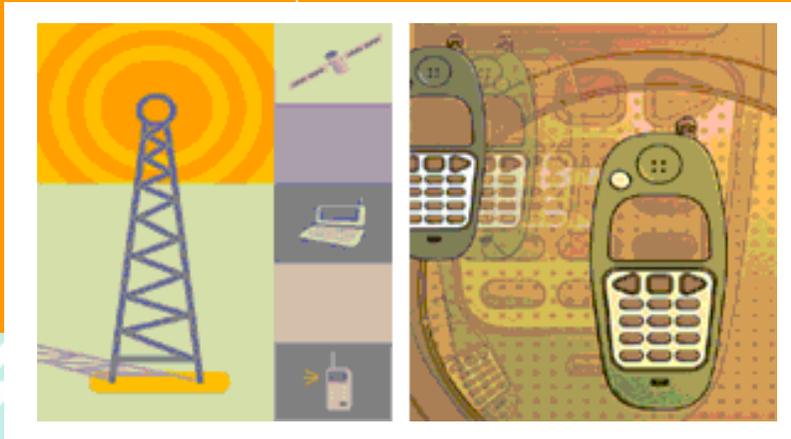
✓ **Computation resources**

  ✓ BB_DSP: base-band processing

  ✓ FBTS_GPP: management

  ✓ FPGA

✓ **Transceiver design**

  ✓ Treatements in FPGA

  ✓ Data Rx / Tx ports inside FPGA

  ✓ Freq Hopping port in DSP

  ✓ Management port in GPP

✓ **Waveform resources mapping**

  ✓ 3 resources

  ✓ 3 processors

  ✓ One on each processor
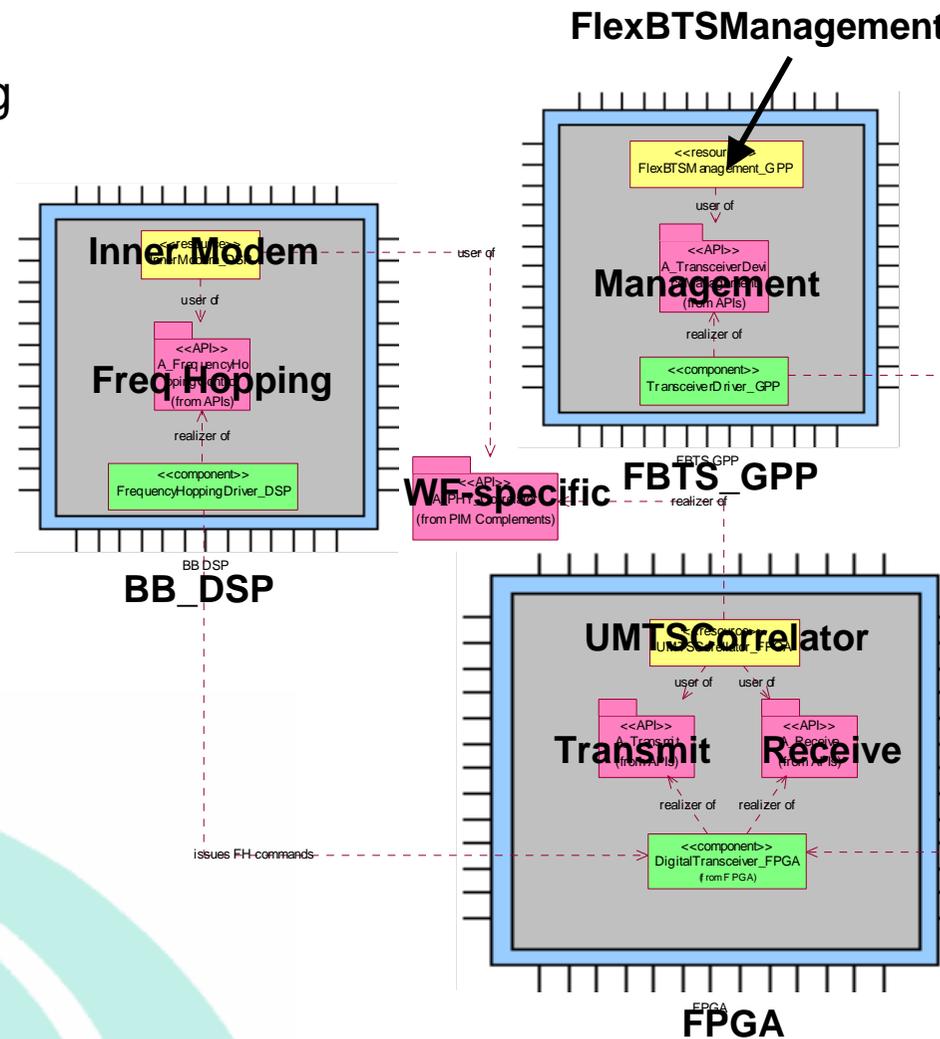
Technical ways forward

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THALES

Features content

✓ Finalization discussion on mature one

✓ Maturing the draft ones

Binding process

✓ Specifically group the associated concepts

    ✓ Interaction types

    ✓ Digital representation types

    ✓ Variability expression for platform bindings

✓ Model: introduction of package _BindingSupport

Verification mechanisms

✓ Describe the essential verification procedures of features

✓ Model: introduce verification-oriented artifacts

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Other needs than strict SDR needs can impact flexible transceivers

- ✓ Regulation compliancy

- ✓ Cognitive radio

- ✓ Smart radio sensing capabilities

Possible new features

- ✓ Feature « Radiation Mitigation »
  - ✓ Complements to Tx channelization mask

- ✓ Feature « Flexible Spectrum Allocation »
  - ✓ Dynamic modification of spectrum plan

- ✓ Feature « Rx snapshot »
  - ✓ Wide-band snapshot acquisition for spectrum analysis
  - ✓ To support Monitoring operations

Standard Modelling profile for SDR Sub-system APIs

- ✓ Structure of the spec and associated stereotypes
- ✓ Positioning versus SWRadio Spec

Standard Waveform bindings

- ✓ Realized at Waveform PIM modelling
  - ✓ Complete modelling
  - ✓ Limited to Transceiver aspects
- ✓ Fixing the Transceiver contribution in such models
  - ✓ Detailed selection of features and required ports
  - ✓ Setting of dimensioning parameters

Standard Platform bindings

- ✓ For consistent business domains bindings
- ✓ To serve as normative references for third parties implementations
- ✓ Examples
  - ✓ The Commercial cellular 3G Transceiver
  - ✓ The Military legacy H/V/U Transceiver

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